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# *A CASE STUDY OF HIGH GRADE SPONDYLOLISTHESIS (GRADE III AND GRADE IV OF MEYERDING SYSTEM) TREATED BY POSTERIOR LUMBAR INTERBODY FUSION*

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**MADURAI.**

# *CERTIFICATE*

This is to certify that the dissertation entitled ***"A CASE STUDY OF HIGH GRADE SPONDYLOLISTHESIS (GRADE III AND GRADE IV OF MEYERDING SYSTEM) TREATED BY POSTERIOR LUMBAR INTERBODY FUSION"*** is a bonafide record of work done by ***Dr. D. PATHI ARASA KUMAR*** in the Department of Orthopaedics, Government Rajaji Hospital, Madurai Medical College, Madurai, under the direct guidance of ***DR.Aa. RAJAMANI, M.S.ORTHO., D.ORTHO.,*** and overall guidance of me.

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# INTRODUCTION

The term spondylolisthesis is derived from Greek word (spondylos – vertebra, olisthesis – to slip or slide down a slippery path). It is defined as anterior or posterior slipping of one vertebra on another. Herbineaux, a Belgian obstetrician was the first to identify it. But the term was first coined by Killian.

Prevalence of spondylolisthesis in general population is 5% and is equal in male and female. Depending on the grade of slip it is graded as grade I to grade IV. High grade slips definitely needs surgical intervention.

Numerous treatment options have been recommended for the treatment of high grade slips. Treatment options include instrumented reduction and achieving fusion by means of any one of the following techniques such as

1. Anterior Lumbar Interbody Fusion **(ALIF)**
2. Transforaminal Lumbar Interbody Fusion **(TLIF)**
3. Posterior Lumbar Interbody Fusion **(PLIF)**
4. Anterior Fusion and Release with posterior fusion (360° fusion)

All these have produced varying degree of success and contributed their own share of complications. We took the option of PLIF with MOSS MIAMI system of rods and screws with stainless steel cage packed with autologous bone graft and evaluated the results for correction of percentage slip.

# AIM

The purpose of this study is to evaluate decompression, reduction and instrumentation for high grade spondylolisthesis with posterior lumbar interbody fusion technique in

1. Alleviating clinical symptoms and signs of mechanical back pain and radicular pain with or without neurological deficit.
2. Achieving the correction of the % slip.
3. Avoiding the progression of slip.

# ANATOMY

## LUMBAR VERTEBRAE

The bodies of lumbar vertebrae increase in breadth from above down, and this is reflected posteriorly by a progressive widening between the articular processes. Thus in L1 and 2 the four processes make a rectangle set vertically; in L3 they may also make a vertical rectangle, or they may be like those of L4 and make a square; in L5 they make a horizontal rectangle. The body shares with the smaller thoracic vertebrae the characteristic of being concave from above down, of having pedicles to its upper half, and of being perforated by a pair of basivertebral veins posteriorly. It differs from the heart shaped thoracic vertebra in being kidney shaped, and the posterior surface is flatter, less concave from side to side, so the vertebral canal is somewhat triangular in cross section.

The transverse processes are variable in length, but the third is usually the longest. The transverse process of the fifth, however, is quite characteristic. Short, Massive, triangular, its base is attached to both the pedicle and the lateral side of the body itself. It is the only vertebra in which the transverse process joins the body (instead of the junction between pedicle and lamina).

The pedicles enclose intervertebral foramina similar in formation to the thoracic foramina, the laminae do not show such a downward slope as in the thoracic vertebrae. The quadrangular spinous process is roughly horizontal. The upper border is straight but lower border is concave.

The articular processes are characteristic. The upper pair rise up and carry articular facets that face medially. The lower pair of articular process project down, face laterally and are convex from front to back.

The transverse processes are fused ribs (costal elements). The true transverse element consists of two small elevations with a groove between them made by the medial branch of the posterior ramus of the overlying lumbar nerve. The mamillary process is a convexity projecting back form the margin of the superior articualr process; the smaller accessory tubercle lies below this, at the root of the transverse process.

The inferior articular processes of the fifth lumbar vertebra face well forwards, and are received into back-ward-facing facets on the sacrum, and this locking prevents L5 vertebra from sliding forwards down the slope of S1 vertebra. Furthermore, the adjacent bodies are strongly united by the intervertebral disc. Thus, although the sloping lumbosacral joint carries the whole body weight, it is extremely stable. A strongly contracting erector spinae

acts as a supporting strap posteriorly. However, if the neural arch is disrupted between the superior and inferior articular processes, i.e. in the so – called pars interarticularis, the body of L5 tends to slip downwards and forwards (spondylolisthesis).

The fifth lumbar vertebra may be fused on one or both sides to the first sacral vertebra, a condition known as ‘sacralization’. More rarely the first sacral vertebra may be partially or completely separate (‘lumbarization’).

**Sacrum**

Five progressively smaller sacral vertebrae and their costal elements fuse to make this bone, which is triangular in outline and curved to a concavity towards the pelvis. On its lateral aspect it has an auricular surface for articulation with the ilium to make the upper posterior wall of the pelvis. Below the sacroiliac joints the sacrum tapers off down to its apex. The upper surface of the first sacral vertebra forms the base of the sacrum. The body of S1 vertebra is large, and wider transversely; its anterior projecting edge is the sacral promontory. Lateral to the body is the wing-like ala of the sacrum on each side, consisting of fused costal element and transverse process. The ala is crossed anteriorly by the sympathetic trunk, lumbosacral trunk and obturator nerve, in that order from medial to lateral. In the anatomical position the upper surface of the base slopes downwards and forwards at 30° or more. From here the sacrum is directed backwards before curving down over the pelvic cavity.

# CLASSIFICATION

Spondylolisthesis is classified by Neugebouer and Newman into 5 clinical groups.

1. Congenital or dysplastic
2. Isthmic
3. Degenerative
4. Traumatic
5. Pathological

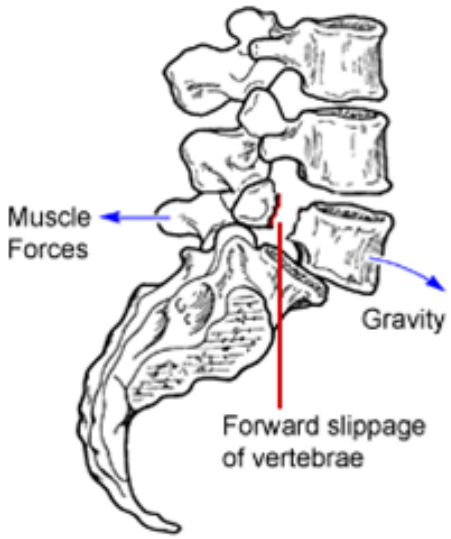
**Congenital or dysplastic**

Forward displacement of a vertebral body occurs at birth. Spinal defect is usually one of the multiple congenital anomalies.

In true dysplastic spondylolisthesis lesion may be either dysplasia of upper sacrum specifically in facet joints or attenuation of pars interarticularis. As the slip increases and as the pars becomes increasingly stretched, it may eventually break thus the break is secondary to slip and is not the cause of slip. This form slip occurs early in life and the degree of slip is marked. Important clinical feature of the lesion is that often there is a lack of defect in pars. As there is no defect, the neural arch comes forward with the slipping vertebra, and the cauda equina may be compressed between the laminae of L4 and L5

vertebrae and the dorsal area of S1 body. Onset may be quite sudden and is called “listhetic crisis”. It is unlikely that the patient will make a complete recovery without surgical intervention. It is unwise to reduce the slip. Evidence of root tension or impairment of root conduction will need laminectomy. All patients need stabilization and the best method of fusion to date is Ala – transverse fusion.

**2. Isthmic type**




a. Lytic : It is the fatigue fracture of pars. Commonly occurs at L5 (89%)
    1. Defect in pars interarticularis of neural arch.
    2. Lesion occurs between the ages of 5 & 7 forward slipping of vertebral body occurs commonly between ages of 10 & 15 and rarely increases after age 20.

3. Primary restraint to progression is strong ilio lumbar ligament, large L5 transverse process, disc and annulus, deep seating of L5 below intercristal line
4. It can occur without producing symptoms, the mere radiological demonstration of the defect in a patient with back ache doesn't indicate that the source of symptom has necessarily been demonstrated.

b. Elongated

It represents repeated micro fracture of pars that heal in elongated position.

c. Traumatic

Pars defect occurs due to trauma either from forced hyper extension or from forced flexion strain. Healing of lesion on immobilization is irrefutable evidence of traumatic origin of the lesion.

**3. Degenerative**

Junghann's used the term pseudo spondylolisthesis for this type, later renamed by Newman as "degenerative spondylolisthesis". The slip is never great, most commonly occurs at L4 - L5 interspace and is common in females. L4 - L5 segment of the lumbar spine is normally the site of greater mobility. In a L4 – L5 degenerative listhesis, it is this excessive mobility combined with

more sagittal alignment of facet joints, that results in the lesion, often accompanied by spinal stenosis.

**4. Traumatic**

Trauma leading to dislocation of posterior joints or fracture of spinous process extending into the lamina at pars. An acute traumatic slip can be openly reduced and maintained in reduce position with the use of instrumentation and fusion.

**5. Pathological**

Generalized bone diseases such as osteogenesis imperfecta, Achondroplasia or localized bony change such as secondary deposit or Paget's may cause attenuation of pedicles, and allow the vertebra to slip forward.

## Iatrogenic

Secondary to aggressive surgical intervention that destabilizes spinal segment is not included in this classification. It occurs most commonly in spinal stenosis decompression without fusion when too much of facet joint is removed which allows for a later slip at surgical level.

# BIO MECHANICS

**Degenerative listhesis:** It is differentiated from isthmic type by intact pars. Because arch is intact it moves forward with L4 body, progressive canal stenosis occurs in addition to facet degenerative changes.

## Theories

### Sagittal facet theory

Predilection for slippage because of facet orientation that does not resist anterior translation forces and over time results in degenerative listhesis.

### Disc degeneration theory

Disc narrows first and overlapping of facets results in accentuated arthritic changes, secondary remodeling and antero listhesis.

Regardless of the exact nature of inciting agent this instability causes facet arthritis, disc degeneration and ligament hypertrophy.

Degenerative listhesis is unstable in adults and it is a translational type of degenerative segmental instability according to **Frymoyer**[1]. Patients usually have recurrent episodes of back pain along with extensor weakness. Classical X ray signs include traction osteophytes and vacuum disc. Females are affected 5 times more common than men and is usual after the age of 40 years. It usually involves L4L5 interspace. Facet joint angulation has been implicated as a cause

of deformity. Boden et al found that patients with degenerative listhesis had a mean facet orientation of 60° compared with 41° in asymptomatic volunteers.

**(Boden .S.D. et al – 1996)[2]**

**Adult isthmic Listhesis**

It is non progressive. The most common abnormality seen is a stress fracture or fatigue fracture of pars interarticularis which is present in 5-6% of the normal population by the end of skeletal growth. 75% of patients with spondylolysis also demonstrated spondylolisthesis, but slip progression is rarely observed **(Fredrickson BE, Baker D, Mc.Holick WJ et al – 1984)**.

Defect in pars interarticularis that interferes with bony hook of affected spinal motion segment. Bony hook consists of pedicle, pars and inferior articular facet of cephalad segment and the superior articular facet of caudal segment. This structural linkage is weakened and can no longer withstand translational instability and the body slips forward. Progression is rare with L5 listhesis due to the restraints to the progression as described already. Callus forms at the pars, fibro cartilaginous tissue also is present in the area of pars from failed attempts to heal the stress fracture. Hook protrudes anteriorly from the bone with superior articular facet over growth both of its narrow the neural foramen. Once the nerve is tethered within the foramen, further slipping mechanically stretches the nerve over the sacrum contributing to radiculopathy.

# CLINICAL FEATURES

1. Back pain: from instability of the affected segment
2. The leg pain: usually is related to irritation of nerve root.
3. Physical findings vary with the severity of slip
   with significant degree of slip
   A step - off at LS junction is palpable.
   Motion of lumbar spine is restricted
   Hamstring tightness is evident on SLR
   Trunk is shortened
   Absence of waist line
   Lordotic posture above the level of slip
   Sacrum becomes more vertical
   Buttock appears heart shaped

Children walking with a peculiar spastic gait “pelvic waddle” because of hamstring tightness and LS kyphosis seldom have objective signs of nerve root compression. Tight hamstrings often are the only positive physical finding.

Scoliosis is common in young patient.

Idiopathic
Sciatic
Olisthetic

# INVESTIGATIONS

## I) Plain radiography

### Views

Anteroposterior

Standing lateral view

Ferguson's AP view (30 degrees caudal tilt)

Oblique view ("Scotty dog" profile)

Dynamic radiography - Flexion - extension lateral views

Compression - traction radiography

## Uses of special views

- Identifies lucency suggesting pars fracture in case of isthmic type.
- Loading of the spine to translate any listhesis, making it and the pars fracture more visible.
- Identifies as many as 19% of pars fracture that would be missed otherwise.
- Preop planning and for identifying hyper mobility.
- Ferguson's AP view is useful in the postoperative assessment of posterolateral fusion mass which is often obscured by the sacral ala on routine AP view.

## II) MRI

Non invasive screening tool for

Detection of compression on neural elements

Early identification of disc desiccation

Evaluation of spinal stenosis

Facet over growth

Hypertrophy of ligamentum flavum

Synovial cysts of facet joints

**Sagittal Images**

Disc

Spinal canal

**Parasagittal Images**

Detail of neural foramina on T1-W images

T2 – W images shows disc degeneration.

## III) Bone Scintigraphy

This is not required for the diagnosis of Adult isthmic spondylolisthesis, but it may be helpful in excluding other condition that can cause similar symptoms. It is useful to detect occult spondylolysis.

## IV) CT myelography

It is a dynamic study that allows observation of spinal fluid that flow along the nerve roots and conusmedullaris.

**Indications:-**

1. Radicular complaints with multiple foci of pathology on MRI
2. Continued Radiculopathy in the absence of MRI findings.
3. Radiculopathy and significant deformity that precludes the use of MRI
4. Contraindications to MRI

For optimal reconstructions 1-1.5mm cuts should be obtained through the area in question. Helical CT can be used with 3mm cuts.

## V) Discography

It is useful in preoperative evaluation

**Indications:**

It is of immense useful in patients with multiple degenerated segments to locate the site of origin of pain. If pain is identified at a single segment or atmost two segments, fusion can be done with more reassurance of improvement.

## VI) SPECT bone scan

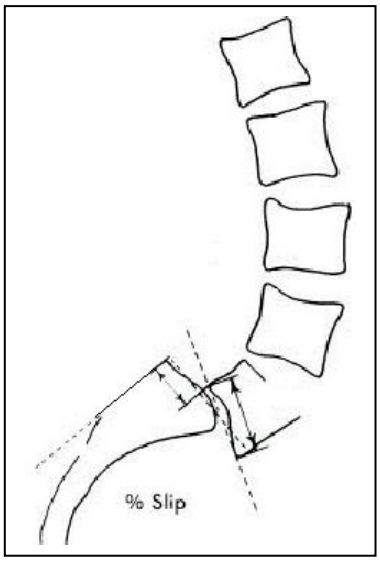
It shows whether there is increased uptake in pars interarticularis. If increase uptake is confirmed, CT scan can be obtained to evaluate whether there are thickened cortices consistent with stress reaction or whether it is an acute stress fracture.

# PLAIN RADIOLOGY

It is the key to diagnosis.

Roentgenographically spondylolisthesis is graded by Meyerding in to 4 grades. Slipgrade is calculated by determining the ratio between the AP diameter of top of S1 and the distance the L5 vertebra has slipped anteriorly.

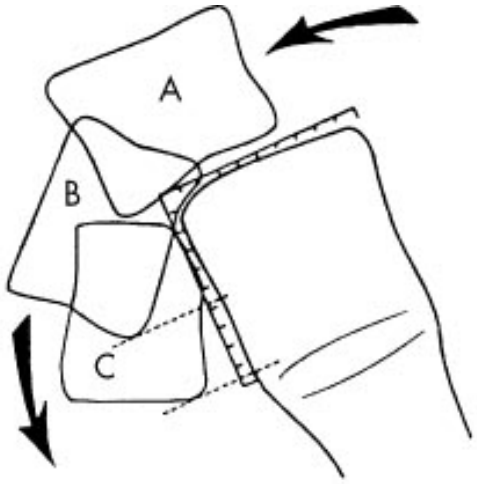
| | | |
|---|---|---|
| Grade I | - | ≤ 25% |
| Grade II | - | 25% - 50% |
| Grade III | - | 50% - 75% |
| Grade IV | - | > 75% |




Dewald recommended a modification of Newman system to better define the amount of anterior roll of L5.

The dome and anterior surface of sacrum are divided into 10 equal parts. Scoring is based on the position of posterior inferior corner of body of L5 with respect to the dome of sacrum. Second number indicates the position of anterior

inferior corner of body of L5 vertebra with respect to the anterior surface of S1 segment.




According to Boxall et al, the angular relationships are the best predictors of instability or progression of spondylolisthesis expressed as “slip angle”. It is calculated by the intersection of lines drawn parallel to the inferior aspects of L5 vertebra and a line drawn perpendicular to the posterior aspect of body of S1. For this calculation lateral views are taken with patient in standing position. Boxall et al, found an association between high slip angle (>55°) and progression of deformity, even after a solid posterior arthrodesis.

Patients with this high grade listhesis tends to have

(a) mechanical instability of spine

(b) radicular pain

# TREATMENT

**Non operative**

**Operative**

## I. Non Operative

It is instituted in patients with minimal symptoms and mild slippage

a) Restriction of patients activities.

b) Generalized aerobic conditioning, cessation of smoking, the use of moist heat and stretching, and a course of nonsteroidal anti-inflammatory medication.

c) Spinal, abdominal, trunk muscular rehabilitation.

d) Intermittent use of rigid back brace.

e) Fluoroscopically guided selective nerve root injection (SNRI) with corticosteroid – series of 3 injections 3 weeks apart is routinely done.

- relieves the patients of symptoms there by allowing them to do aggressive exercise programme.

In symptom free patients with slip 25% to 50%, Wiltse recommended

avoiding contact sports

avoiding activities that carry high probability of back injury.

Standing spot lateral roentgenogram of LS junction are made every 6-12 months until the completion of growth. This is especially important in female with high risk for progression of slip.

## II. Operative

### Indications

1. Most common indication for surgery is persistent, unacceptable back pain and leg pain.
2. Radiculopathy
3. Neurologic worsening
4. Slip progression

### Surgical options

1. Pars repair
2. Decompression
3. Fusion
    a. Insitu
    b. Bilateral postero lateral
    c. Anterior Lumbar Interbody Fusion (ALIF)
    d. Trans Foraminal Lumbar Interbody Fusion (TLIF)
    e. Posterior Lumbar Interbody Fusion (PLIF)
    f. Posterior instrumentation with reduction and fusion

g. Anterior fusion and release with posterior fusion (360° fusion)

4. Cast reduction and fusion

**1. Pars repair**

If the pars defect is the major source of the pain and radicular signs are absent, a high rate of success can be expected. Direct repair of the defect in the pars interarticularis involves decortication, autologous grafting, and osteosynthesis across the ischemic defect. Fixation is by means of tension band wiring and direct fixation with either hook or screw.

**2. Decompression**

**Without Fusion**

Lumbar decompression without fusion is done in patients with symptoms of radiculopathy or Neurogenic claudication and significant antecedent stabilizing disc degeneration.

**Techniques**

1. Gill's laminectomy decompression
2. Fenestration decompression (Limited decompression)
3. Hemilaminectomy

Gill's eponymous procedure, consisting of removal of the loose posterior arch and decompression of the nerve roots and cauda equina, has been

noted to be associated with a significant risk of symptomatic slip progression, particularly in young patients. **(Gill GG, Manning JG, White HL – 1955)[3].**

**With fusion**

Indications are

a. Preserved disc height

b. Osteoporosis

c. Absence of osteophytes on plain radiology

d. Minor non-pathological motion on dynamic radiography

Outcomes are better with the addition of fusion and it has now become a standard.

## TYPES OF FUSION

1. Postero lateral fusion
2. Interbody fusion

**Postero lateral fusion**

This is recommended for slips >50% in children and adolescents, whose symptoms persist despite conservative treatment. Laminectomy as an isolated procedure is contraindicated. All cases of spondylolisthesis does not need reduction, for eg., low grade isthmic type of listhesis in adults are surgically treated better with insitu fusion with 90% good result. True AP (Ferguson's)

view of LS junction is taken to evaluate the success of arthrodesis. For adult patients with isthmic spondylolisthesis it is a standard treatment fusing from L5 to S1 with or without instrumentation using autogenous bone grafting. Kim and lee were unable to demonstrate a difference in outcomes between patients treated with posterolateral fusion with pedicle screw fixation and anterior interbody fusion **(Kim NH, Lee JW – 1999)[4].**

**Interbody fusion**

Ideal indications for interbody fusion includes.

1. Single level axial back pain with radiculopathy
2. Minimal disc degenerative changes
3. Preserved disc height
4. Small or absent transverse processes at the level to be fused.

## TECHNIQUES

1. ALIF
2. PLIF
3. TLIF
4. Posterior instrumentation with reduction and fusion
5. Anterior fusion and release with posterior fusion (360° fusion or circumferential fusion)

## ALIF (Anterior Lumbar Interbody Fusion)

This may be performed alone or with supporting posterior instrumentation.

### Advantages

- Wide access to the disc space and provision for complete disectomy lead to higher fusion rate.
- Complete ligamentous release
- Avoidance of posterior muscle stripping
- Avoidance of epidural scarring
- Structural support of anterior column

### Disadvantages

- Difficulty in achieving rigid fixation
- Potential for graft failure or migration
- Risk of injury to iliac veins and autonomic plexus. Producing bleeding and genito urinary complications.

The spine is approached anteriorly through a retroperitoneal approach which provides access to all lumbar vertebrae from L1 to sacrum. The transperitoneal approach is limited to intervertebral levels above L4 because mobilization of great vessels and hypogastric plexus pose difficulty.

## PLIF (Posterior Lumbar Interbody Fusion)

It affords the surgeon the opportunity to fuse all three columns of the affected spinal segment through single posterior incision. PLIF has a sound biomech rationale because the compression forces in the lumbar spine passes anteriorly through the disc space.

The technique was introduced first in 1945 by CLOWARD to treat lumbar disc herniation. The initial popularity declined as high rate of pseudoarthrosis and graft dislodgement became evident. Recent advances in instrumentation and technique have resulted in an increased use of PLIF technique with threaded interbody fusion cages.

The technique requires adherence to the following 4 principles

1. Preserve the integrity of posterior motion segment that serves to stabilize and compress the graft.
2. Preserve the cortical endplates to avoid seating the graft in the soft cancellous bone of vertebral bodies.
3. Achieve maximal removal of disc material.
4. Fill the disc space with compacted autogenous bone graft.

**(McAfee, complete versus partial discectomy-2002)[5]**

**(Lin PM. PLIF technique – 1983, 1985)[6,7]**

**Advantages**

1. Single posterior approach.
2. Correction of slip angle.
3. Preservation of disc height.
4. High rate of union.
5. Avoidance of second surgery for anterior column support.
6. Avoidance of injury to hypogastric plexus and the associated risk of retrograde ejaculation.

**Disadvantages**

1. Technically difficult
2. Risk of graft displacement
3. potential destabilization of anterior and posterior column
4. Increased risk of nerve root injury, dural tears, epidural fibrosis from excessive retraction.

Okuyama encountered a very low risk of fusion and hardware failure but noted a higher risk of neurologic impairment, with 8% of patients suffering from a temporary palsy. **(Okuyama K, et al – 1999)[8].**

**Contraindications**

1. Epidural scarring that prevents mobilization of roots
2. Osteoporosis
3. Pathology above the mid lumbar level especially the conus level or above

## TLIF (Transforaminal Lumbar Interbody Fusion)

It was described by Harms as a variant to PLIF, requiring less neural element retraction, thereby reducing risk for neural injury. Because significant thecal sac retraction is not required, TLIF can be performed at higher lumbar levels. There are no significant differences in blood loss, duration of hospital stay, and operative time between the PLIF and TLIF, but complications are less than those of PLIF **(Humphreys. S.C. et al – Spine 2001)[9].** Interbody fusion is accomplished by single or two cages. TLIF can be done unilaterally or bilaterally. The putative advantages of anterior interbody fusion include the ability to thoroughly resect the presumably symptomatic disc, as well as the ability to place a structural graft in the interspace. Indirect nerve root decompression is achieved by restoring the interverbral disc space height, thereby reversing the vertical descent that narrows the neural foramen. Anterior column fusion can be achieved through a transforaminal posterior, or a direct

anterior approach. The transforaminal interbody fusion is now in widespread use; it affords the ability to graft the anterior and posterior columns, to directly decompress one or both L-5 roots, and to achieve rigid posterior fixation **(Harms J, Tabasso G. – 1999)[10].**

## CIRCUMFERENTIAL FUSION

It implies a separate anterior and posterior incisions and approach to spine. It is a technically demanding procedure and associated with high rate of complications. Most reasonable in patients with marker instability or significant anterior bone loss (eg., osteomyelitis). In degenerative disease, this is considered only in those with severe disability and usually previous multiple failed spinal operation. Other indications include

1. Patient at high risk for pseudoarthrosis
2. Multi level involvement and marked segmental instability (infection and trauma)
3. Anterior column support in patients with significant osteoporosis

The combined interbody and PL fusion was shown to be very effective in achieving fusion and preventing progression in cases of high grade spondylolisthesis **(Lindholm.TS, Ragni P., Ylikoski M. et al – 1990)[11].**

Interbody fusion is accomplished by means of cages may be

1. Allograft
2. Bone dowels
3. Metal cylinders filled with bonegraft

Bone dowels, cages biomechanically appear to be equivalent. Both implants appear to be susceptible to loosening with cyclic fatigue when used alone. Further stabilization is there fore needed and is best provided by pedicle screw implants.

Fusion rates are better with instrumentation

Fusion rate is 87% in patients with instrumented fusion

Fusion rate is 30% in patients with uninstrumented fusion

Pedicle screw implants appear to be better for maintaining anatomical alignment than distraction constructs and Luque rods or Rectangles which are reported to worsen anterolisthesis. Fusion rates are also higher (86%) with pedicle screws than with rod constructs (69%).

**Causes for failure of fusion**

1. Tobacco abuses the most significant factor for failure of fusion.
2. Use of anti-inflammatory medication.

3. Un instrumented attempt at fusion.

**Complications**

1. Wound infection – rate is higher with instrumented fusion
2. Adjacent segment degeneration is accelerated
3. Graft failures secondary to fracture and collapse
4. Pseudoarthrosis
5. Neurological impairment
6. SIADH syndrome (syndrome of inappropriate antidiuretic hormone secretion)

**3. Reduction**

Low-grade slips are typically treated with fusion insitu with acceptable results, but this is not so with high grade slips. The pathologic anatomy of high grade slips involves lumbo sacral kyphosis, which begins once the anterior translation of L-5 on S1 exceeds 50%. In addition to cosmetic alteration, hyperlordosis develops above the L-5 slip to balance the trunk over the pelvis which then lead to back pain, facet joint arthrosis, and central and lateral recess stenosis above the L-5 to S1 level. Root compression is more common in high grade slips. In addition it may lead to stretching of the sacral nerve roots over the L5 to S1 disc and the posterior aspect of dome of sacrum resulting in cauda equina symptoms. The more complex pathoanatomy seen in high grade

spondylolisthesis has led to the consideration of reduction. A number of techniques for reduction have been advocated and most authors stress the importance of reversing the lumbosacral kyphosis as the primary goal, with reduction of the translation a secondary consideration. It is the kyphosis that has the most significant deleterious effect on the balance of lumbar spine and the trunk and is most important to reverse **(Boachie – Adjei O, Twee D, Rawlins B – Spine 2002)[12].**

Reduction can be performed through a combined anterior and posterior approach or as a stand-alone posterior procedure. Instrumented posterior reduction is now quite popular and can be facilitated with a transforaminal interbody fusion technique. Circumferential approaches include anterior discectomy at L4-5 and L-5 to S-1 with instrumented posterior reduction and fusion. For more severe slips, or cases in which previous surgery has failed, resection of the entire L-5 vertebra through a combined anterior and posterior approach followed by reduction of L-4 onto the sacrum and instrumented posterior L-4 to S-1 fusion **(the Gaines procedure)** is an appealing alternative.

**Advantage of reduction**

1. Reduction reduces the slip angle and places the fusion mass under less tensile stress.

2. Decompresses the anterior portion of sacrum, allowing sacral remodeling.
3. Eliminates the complication of progression of deformity.
4. Physical appearance is a concern of adolescents with high grade spondylolisthesis and this can be improved with reduction of deformity.

**Complications**

High risk of injury to L-5 nerve, as high as 40% have been reported. Though many of these resolve, permanent injury including footdrop with permanent disability can occur. Risk of neurological injury is minimized by

1. Staging the procedure with 1-2 week interval between operation
2. Shortening of the spine by sacral dome osteotomy where excessive axial lengthening is anticipated, using neurologic monitoring, including one or more wake up tests.
3. Accepting partial reduction where necessary.

Reduction technique was combined with restoration of anterior column by a posterior interbody lumbar fusion or anterior interbody lumbar fusion **Marms** found that the use of titanium cage with autologos bone material inserted from posterolateral interbody fusion technique provided anterior column support.

Most authors agree slippage of >50% require fusion.

**Advantage of fusion**

Patients with preserved disc height are prone to instability after decompression and hence fusion should be considered.

**Indications**

Osteoporosis which predispose to pars fracture

Minor nonpathological motion on roentgenography

It gives better functional results and correct sagittal alignment. Fusion rates are better with instrumentation.

Restoration of normal segmental anatomy is of paramount importance at L4-5 and L5-S1 level. The objective of interbody grafts at these levels is to recreate the segmental lordosis of -20° to -28°. This can be done with mesh cages, femoral ring allografts, or carbonfiber trapezoidal cages.

# SCREW INSERTION TECHNIQUE

The locations for screw insertion have been identified and described by Roy-Camille, Saillant, and Mazel and by Louis. The respective facet joint space and the middle of the transverse process are the most important reference points. An opening is made in the pedicle with a drill or hand-held curet, after which a self-tapping screw is passed through the pedicle into the vertebral body. The pedicles of the thoracic and lumbar vertebrae are tubelike bony structures that connect the anterior and posterior columns of the spine. Medial to the medial wall of the pedicle lies the dural sac. Inferior to the medial wall of the pedicle is the nerve root in the neural foramen. The lumbar roots usually are situated in the upper third of the foramen; therefore it is more dangerous to penetrate the pedicle medially or inferiorly as opposed to laterally or superiorly.

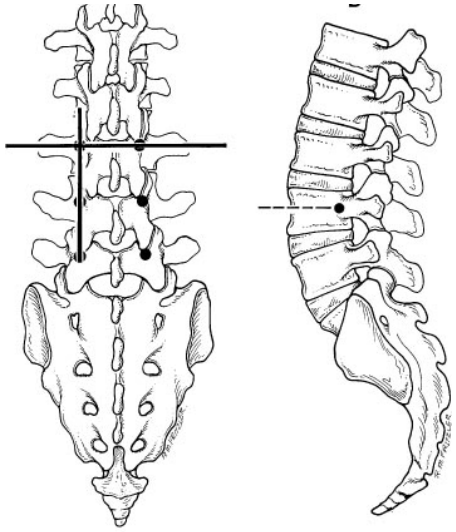
**Techniques for localization of the pedicle in lumbar spine:**

(1) The intersection technique

(2) The pars interarticularis technique

It is important in preoperative planning to assess individual spinal anatomy with the use of high-quality anteroposterior and lateral roentgenograms of the lumbar and thoracic spine, as well as with axial CT scanning at the level of the pedicle.

**The intersection technique**



This is perhaps the most commonly used method of localizing the pedicle. It involves dropping a line from the lateral aspect of the facet joint, which intersects a line that bisects the transverse process at a spot overlying the pedicle.

**The pars interarticularis technique:**

Pars interarticularis is that area of bone where the pedicle connects to the lamina. Because the laminae and the pars interarticularis can be easily identified at surgery, they provide landmarks by which a pedicular dill starting point can be made.

Patients with isthmic spondylolisthesis frequently have a relatively small L-5 transverse process. Furthermore, the nature of the pars defect is such that the lateral aspect of the pars interarticularis is not available for decortication

and bone grafting. It is therefore essential, when pedicle screw instrumentation is used, to start the L-5 screw as far medially as safely possible to leave the maximum possible surface area of the transverse process for decortication and grafting.

# MATERIALS AND METHODS

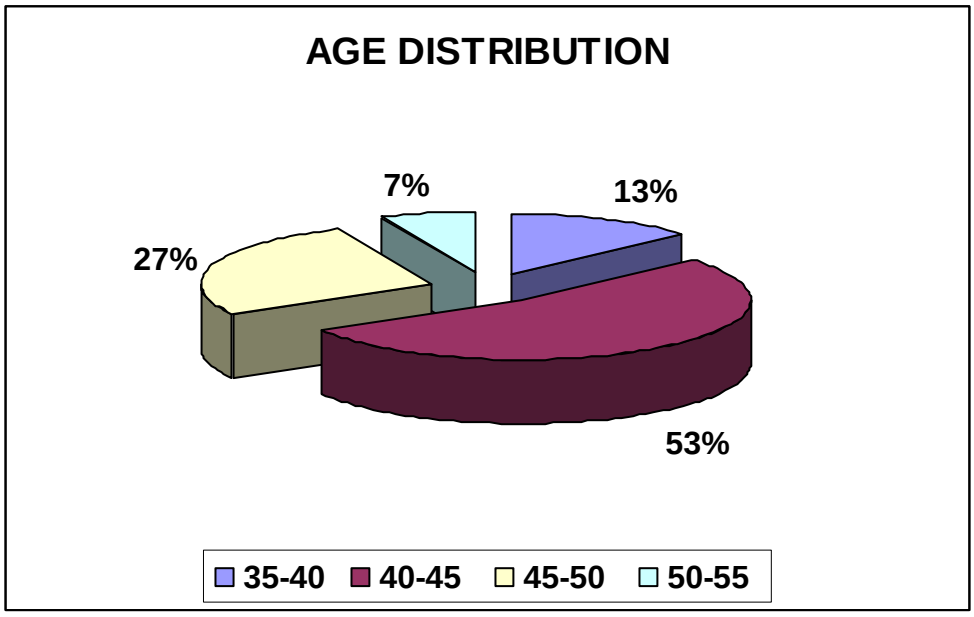
We operated upon 15 patients with high grade spondylolisthesis at our institution, 11 were females and 4 were males. We used **Meyerding system** of grading in our series and **patients in our study belonged to Grade III and Grade IV spondylolisthesis.** 12 patients belonged to grade III and 3 belonged to grade IV of Meyerding's system. Age of the patients ranged from 35-55 yrs. The period of study was from June 2004 to June 2006. All patients were followed regularly and the average period of follow up was 14 months.

All our patients came under the category of isthmic type of spondylolisthesis. All our patients had unremitting back pain, leg pain with or without neurological deficit (EHL weakness Grade 4/5 in 3 cases). Dynamic plain radiography of all our patients showed spinal instability.

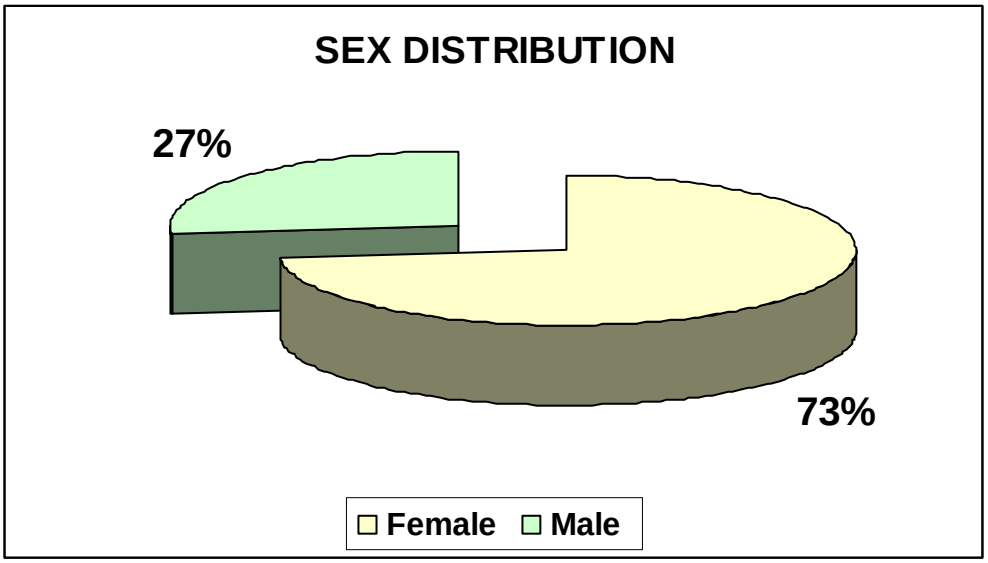
Patients with low grade spondylolisthesis (Meyerding Grade I and II) and spondyloptosis were excluded from our study.

Implants used were MOSS Miami system of rods, 5mm pedicle screws (mono axial, poly axial), stainless steel cage.

| Age group | PLIFF | |
|---|---|---|
| | No. of patients | Percentage |
| 35-40 yrs | 2 | 13.33 |
| 40-45 yrs | 8 | 53.33 |
| 45-50 yrs | 4 | 26.67 |
| 50-55 yrs | 1 | 6.67 |
| **Total** | **15** | |
| **Mean** | **44.3 yrs** | |



| Sex | PLIFF | |
|---|---|---|
| | No. of patients | Percentage |
| Female | 11 | 73.33 |
| Male | 4 | 26.67 |



| S.No. | % Slip | Meyerding's Grading | Dynamic instability |
|---|---|---|---|
| 1 | 55° | III | + |
| 2 | 55° | III | + |
| 3 | 57° | III | + |
| 4 | 58° | III | + |
| 5 | 58° | III | + |
| 6 | 60° | III | + |
| 7 | 60° | III | + |
| 8 | 63° | III | + |
| 9 | 67° | III | + |
| 10 | 70° | III | + |
| 11 | 70° | III | + |
| 12 | 72° | III | + |
| 13 | 77° | IV | + |
| 14 | 77° | IV | + |
| 15 | 80° | IV | + |

## Pre operative planning

Plain radiography in AP view to identify any lucency in pars region suggesting fracture, reactive sclerosis, lateral view in standing position to load the disc and to translate any spondylolisthesis, flexion- extension lateral view to identify hypermobility were taken.

Pre operative MRI was done to detect compression of neural elements and disc desiccation. Sagittal images to delineate the disc and spinal canal, parasagittal sequences for delineating neural foramen on T1-weighted images.

After initial clinical and radiographic evaluation, patient was taken up for surgery.

## Operative technique

**Anaesthesia:-**

General anaesthesia in supine position.

**Position:-**

Patient is then changed to prone position after the induction of anaesthesia with the bladder on catheter with two transverse pillows, one below the chest and the other underneath the pelvis so that abdomen is not compressed. Eyes are protected with cotton pads. Shoulders are placed in 60° abduction over the arm boards.

**Image intensifier:-**

They are used for the assessment of reduction of the slipped vertebra and of drilling trajectory.

**Tumescent Injection:-**

| | | |
|---|---|---|
| Adrenaline | - | 1 ml (1:1000) |
| Sodiumbicorbanate | - | 10 ml (7.5% w/v) |
| Hyalase | - | 1 ampoule |
| Lignocaine (2%) | - | 30 ml |
| Normal saline | - | 450ml |

Solution is prepared from these drugs and about 100ml is injected down to the level of laminae to minimize the bleeding.

**Incision:-**

Posterior midline incision centered over the spinous process of the forwardly slipped vertebra extending one above and one below it. During the procedure when the incision is not adequate enough, we prefer to extend the incision rather than strong retraction to avoid the muscle necrosis which may predispose to infection.

**Procedure:-**

Transverse process of L4 or L5 are exposed bilaterally. Sacral ala were exposed in cases where sacral screws insertion were planned preoperatively.

## Pedicle screw instrumentation

Guide wire was inserted at the infero lateral aspect of superior articular facet. Entry point was made easy by projecting the view of c-arm in AP plane and the trajectory of the wire was made easy by projecting the view of c-arm in lateral plane. Once position was confirmed, the guide was removed and the hole was enlarged with a pedicle probe with care not to penetrate the pedicle walls. All the 4 walls of the pedicle was then assessed with ball tipped probe for its intactness. The hole was then tapped with 5mm cancellous tap and 5mm pedicle screw as per length measured with guide wire assistance. Either mono axial or poly axial screw was inserted.

The remaining three pedicle screws were inserted in the same manner and the position and length of the screws were confirmed with c-arm guidance in AP and lateral view.

## Decompression

Once pedicle screws were inserted, we proceeded with decompression of nerve roots by doing laminectomy of the slipped vertebra, as well removing uncovertebral osteophytes if any and made sure that the nerve root was thoroughly decompressed. Perineural adhesions if any present was also released. Mobility of the root was assessed under direct visualization. Fusion bed was then prepared by decorticating the transverse processes bilaterally at

the level to be fused. Sacral ala was prepared if the level of fusion includes L5S1. Care was taken to leave intact the immediate proximal functional joint for eg., we leave intact the L3L4 facet capsule, supraspinous, infraspinous ligament between L3L4 if the level of fusion was planned to be L4L5. The morselized posterior elements was preserved as a graft source for interbody fusion.

## Cage placement and Reduction

MOSS Miami rod was bent to appropriate sagittal contours and was connected to the screw, first to the distal and then to the proximal screw. Temporary distraction was then done to create a adequate working window. The annulus fibrosus was incised with 15 blade knife attached to long BP handle and thorough discectomy was done with disc punch. Vertebral end plates were then removed with 30° to 45° angle osteome and ring curette.

Under image intensification, anterior decortication was then done in the disc space carefully. Morselized autograft was then placed in the anterior 1/3$^{rd}$ of the interspace and impacted. With distraction in place stainless steel cage (12mm) packed with autologos bone graft was then impacted into the disc space so as to occupy the posterior aspect. With the rods attached to the sacral screws and by cantilever maneuver with cage acting as a fulcrum, lumbar lordosis was reproduced and the anterior translation of the slipped vertebrae was corrected.

In case where full correction couldn’t be achieved we accepted partial reduction and we instrumented the spine in that position itself. Compression was then given between the screws to enhance arthrodesis and to increase lordosis production using the structural cage as fulcrum.

**Posterolateral arthrodosis**

With the reduction complete, posterolateral grafting was done. We used morselized bone from the resected posterior spinal elements as the source and when it was found to be inadequate, we used posterior iliac crest as graft source. Routine closure over a deep drain was accomplished. Compressive dressing applied.

Patient turned onto the bed, awaked, and L5, S1 root function verified bilaterally by physical examination.

# RESULTS

The operating time was calculated from the start of surgical incision to wound closure and had not changed significantly throughout the study period. It was about 3.5 hrs.

The blood loss was calculated from the number of surgical mops used each corresponding to 50ml. Blood loss in our series was about 220ml.

The duration of image intensifier usage was calculated in seconds. It varied from 50-100 seconds.

All patients were followed up for an average period of 14 months and the results were analysed.

Clinically by alleviation of back pain and radicular pair.

Radiologically by the correction of % slip.

Radiological union was defined as the presence of fusion mass which was usually seen in an average period of 8-12 months and we achieved union in all the 12 patients who turned up for review. Three didn't turn up for follow up after a period of 6 months and in these patients fusion couldn't be ascertained. The % slip was corrected completely in12 patients, partially corrected in 3

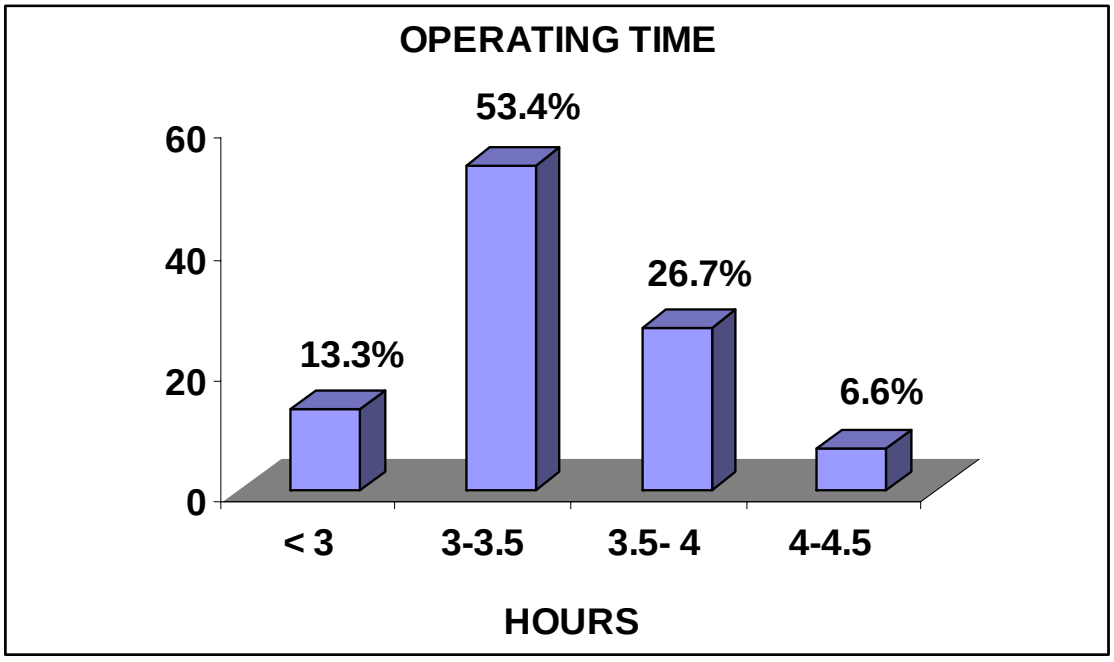
patients and there was no incidence of progression of slip or implant failure at a follow up period of 14 months. Inspite of thorough decompression and stabilization of sagittal spinal balance, 3 of our patients had the complaints of radicular pain postoperatively for a period of 6-8 weeks which then settled down in due course. These patients were allowed an additional period of restricted mobility for 3 months and the drug carbamazepine 200mg BD × 2 weeks.

The average lumbar spine movements was atleast 80% of that of the normal and pain free. All patients regained 80% of their premorbid level of independence.

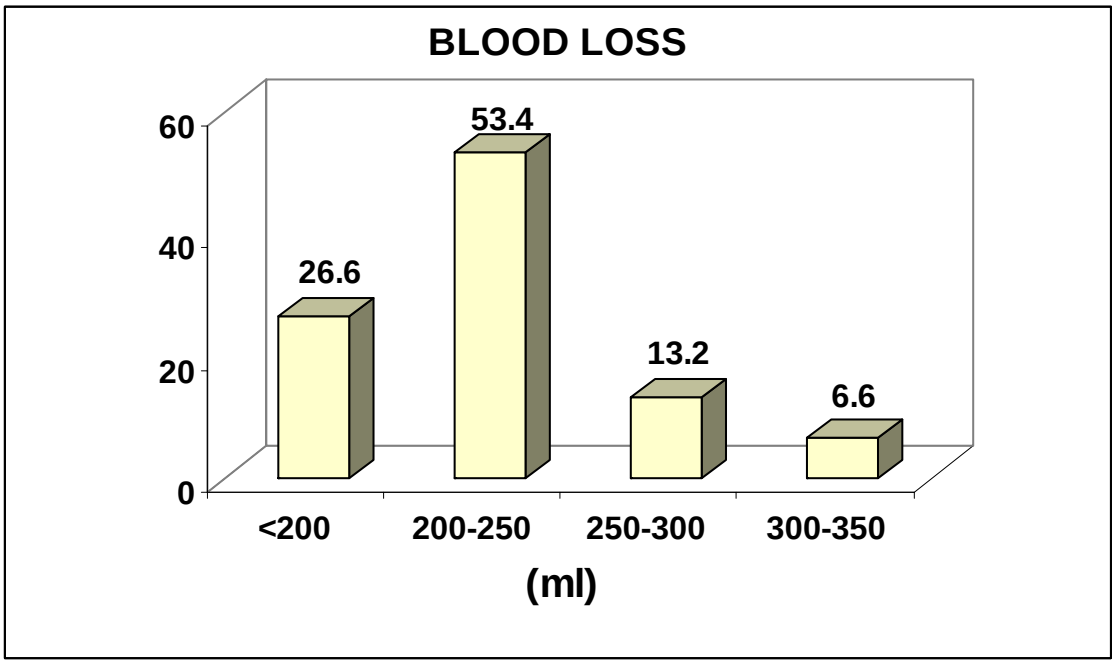
No case of infection was noticed in the postoperative period which might probably be due to the strict sterile technique followed preoperatively and 2 doses of broad. Spectrum antibiotics used, one dose, 2 hrs before surgery and another dose during the middle of the surgical procedure.

We didn’t encounter any neurological deficit in our patients post operatively and the three patients who had motor weakness of Extensor Hallucis Longus (EHL) Grade 3/5 were also normalised to 5/5 after an average period of 8 weeks.

| Operating time | PLIF | |
|---|---|---|
| | No. of patients | Percentage |
| < 3 hrs | 2 | 13.3 |
| 3-3.5 hrs | 8 | 53.4 |
| 3.5- 4 hrs | 4 | 26.7 |
| 4-4.5 hrs | 1 | 6.6 |
| **Mean** | **3.30 mts** | |



| Blood Loss | PLIF | |
|---|---|---|
| | No. of patients | Percentage |
| <200ml | 4 | 26.6 |
| 200-250ml | 8 | 53.4 |
| 250-300ml | 2 | 13.2 |
| 300-350ml | 1 | 6.6 |
| Mean | 230 ml | |



We were able to achieve full correction of % slip in 12 patients where as only partial correction was achieved in 3 patients (1 male; 2 female). All the three patients belonged to Grade IV and they were reduced to Grade III.

| S.No. | Pre operative % Slip | Post operative % slip correction |
|---|---|---|
| 1 | 55° | Complete correction |
| 2 | 55° | Complete correction |
| 3 | 57° | Complete correction |
| 4 | 58° | Complete correction |
| 5 | 58° | Complete correction |
| 6 | 60° | Complete correction |
| 7 | 60° | Complete correction |
| 8 | 63° | Complete correction |
| 9 | 67° | Complete correction |
| 10 | 70° | Complete correction |
| 11 | 70° | Complete correction |
| 12 | 72° | Complete correction |
| 13 | 77° | 30° |
| 14 | 77° | 35° |
| 15 | 80° | 42° |

Our functional results were analysed using the **oswestry scale**.

**OSWESTRY SCALE**

Excellent

Good

| Oswestry Scale | Excellent | Good | Fair |
|---|---|---|---|
| No. of patients | 7 | 8 | |
| Percentage | 46.7 | 53.3 | |

We had excellent functional results in 7patients, 8 patients had good result.

# RESULTS – SUMMARY

| PARAMETERS | VALUES |
|---|---|
| **OPERATING TIME** | 3 hours 30 minutes |
| **BLOOD LOSS** | 230 ml |
| **FLUROSCOPIC EXPOSURES** | 42 seconds |
| | |
| **CORRECTION OF % SLIP**<br><br>**GRADE III**<br><br>**GRADE IV** | <br><br>100%<br><br>60% - 80% |
| **FACETAL VIOLATION** | Nil |
| **SCREW BREAKAGE** | Nil |
| **NEUROLOGICAL DEFICIT** | Nil |
| **INFECTION** | Nil |
| **PROGRESSION OF SLIP** | Nil |

# DISCUSSION

Though the incidence of high grade spondylolisthesis is low in the general population, it is really a great menace to the patient and if left untreated can lead on to complete neurological deficit with or without bladder and bowel involvement. Also treating a high grade listhesis is a difficult task because of its complex pathoanatomy. There is no doubt that high grade listhesis are best treated by surgical means. There are many surgical options at present for treating this complex pathology and each one has its own merits and demerits. There are still controversies whether to fuse them insitu or reduce and fuse. Even with reduction there are controversies whether to reduce them partially or completely and then fuse. Fusion can be achieved posterolaterally or at interbody level or combined and which one to choose among them is also a controversial problem.

Posterolateral insitu fusion is technically a more demanding procedure in high grade slips because L5 transverse process is anterior and inferior to sacral ala and this causes the fusion to be more horizontally oriented putting the fusion mass under high tension and at great risk for failure resulting in increased incidence of pseudoarthrosis and slip progression. The rate of pseudoarthrosis have ranged from 0 to 60%, rate of progression of slip of as much as 25% despite solid arthrodesis. Deformity also persisted.

This has led to the recommendation of reduction high grade slips. Achieving reduction is a difficult procedure and after achieving reduction partial or complete, obtaining fusion can be by means of posterolateral or interbody fusion. Various studies have proved that interbody fusion is better on biomechanical point of view. In a biomechanical analysis, conducted at neurosurgery clinic, Italy, it has been stated that interbody fusion confers superior mechanical strength to the spinal construct and sole posterolateral fusion leads to progressive loss of correction achieved.

**(J. Neurosurgery – 2003)[13]**

There are various approaches to the spine with a goal of achieving solid interbody fusion, each with their own share of success and complications. Among them PLIF appears to afford the surgeon of achieving anterior column arthrodesis and posterior transpedicular instrumentation through the same incision. It is successful in achieving and maintaining disc space height, making it a good option for a patient with mechanical back pain and foraminal Stenosis and resultant radiculopathy.

**Advantages of PLIF**

1. Single incision
2. Correction of lumbosacral kyphosis
3. Correction of percentage slip

4. Promoting and maintaining disc space height
5. Biomechanically superior

In a biomechanical analysis, pedicle screw fixation tended more strongly to increase the rigidity after 1-level, PLIF compared to TLIF.

**(Spine - 2006)[14]**

In an independent review of 71 cases of PLIF with cages, the procedure is effective with 90% fusion rate and 66% overall satisfaction.

**(J. Neurosurgery-1999)[15]**

We achieved 100% correction of % slip in 12 patients with Grade III spondylolisthesis and 50%-60 % correction in 3patients with grade IV spondylolisthesis. The construct was found to be biomechanically superior as we didn't encounter the problem of screw breakage or progression of slip in any of our patients at the end of average follow-up of 14 months but the long term outcome is not known.

# CONCLUSION

Although this study is limited by few number of patients and the duration of follow up is very short, the outcomes suggest that the management of high grade listhesis can be accomplished successfully with PLIF technique.

In conclusion, we would suggest PLIF technique supplemented with posterolateral bone grafting is an ideal technique in high grade listhesis for the achievement of

1. Reduction
2. Direct decompression of nerve roots
3. Interbody fusion
4. Good biomechanical support by pedicular instrumentation

This technique is also advisable in view of low complication rate.

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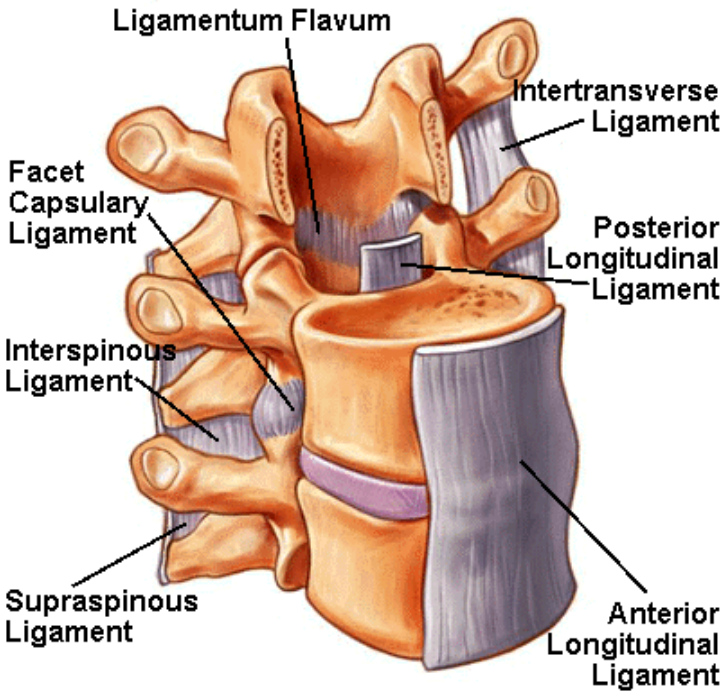
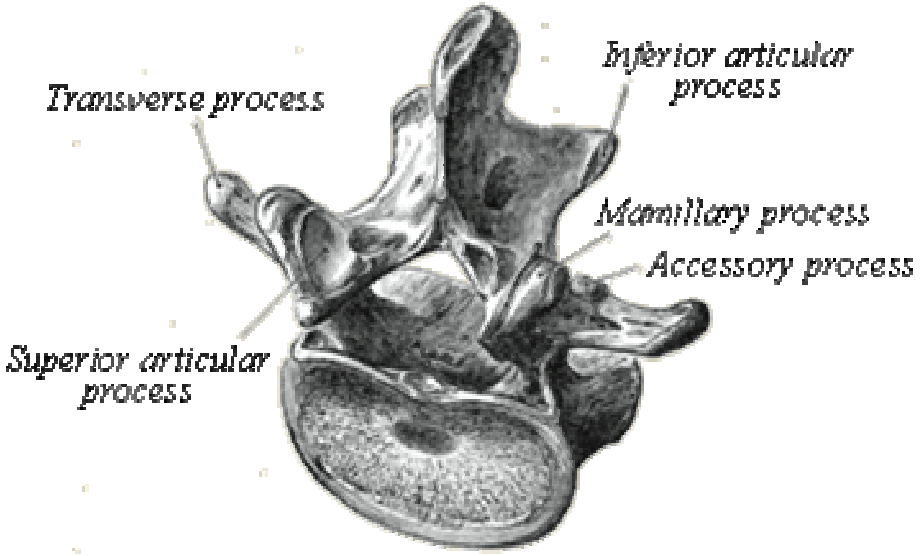
## LUMBAR SPINE




## LUMBAR SPINE



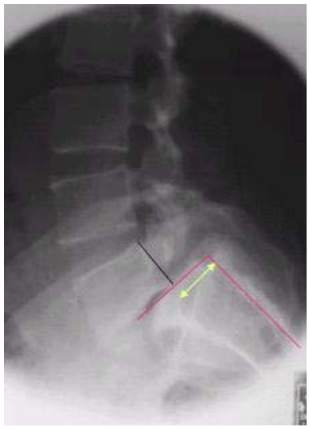
# CLINICAL RESULTS

## Case 1 – Pre op

Grade III spondylolisthesis
Back pain, radicular pain
Mechanical instability was present

**Lateral View**

**% SLIP - 60º**



**MRI**

**Case 1 – Post op**

**A.P.VIEW**


**LATERAL VIEW**

**Case 2 Pre op**

Grade III spondylolisthesis
Back pain, radicular pain were present
No neurological deficit
Mechanical instability was present

**LATERAL VIEW**

**% SLIP - 55º**

**MRI**

**Case 2 – Post op**

**AP VIEW**

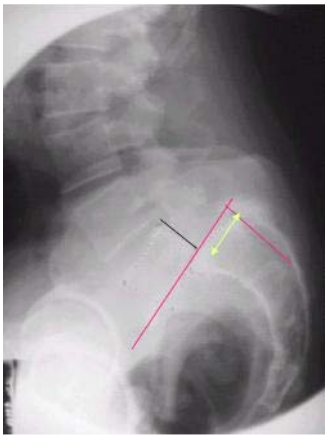
**LATERAL VIEW**

## Case 3 – Pre op

Grade IV spondylolisthesis
Back pain, radicular pain were present
Extensor hallucis longus weakness was present on the left side (power = 4/5)
Mechanical instability was present

**LATERAL VIEW**

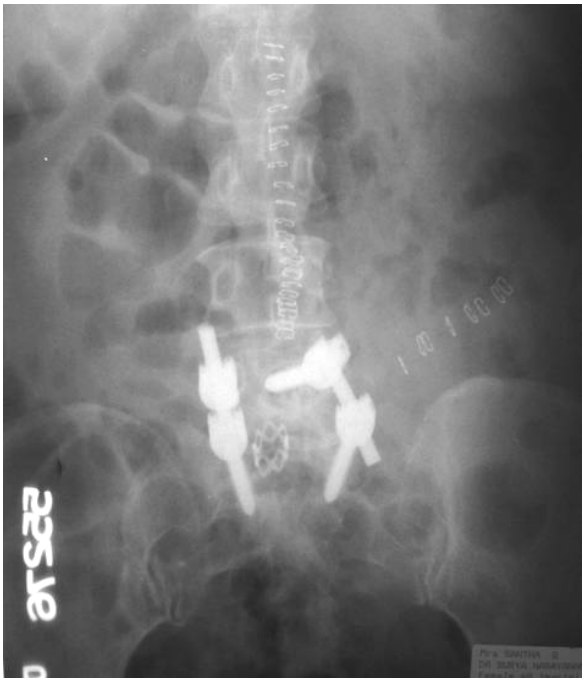
**% SLIP - 80º**



**MRI**

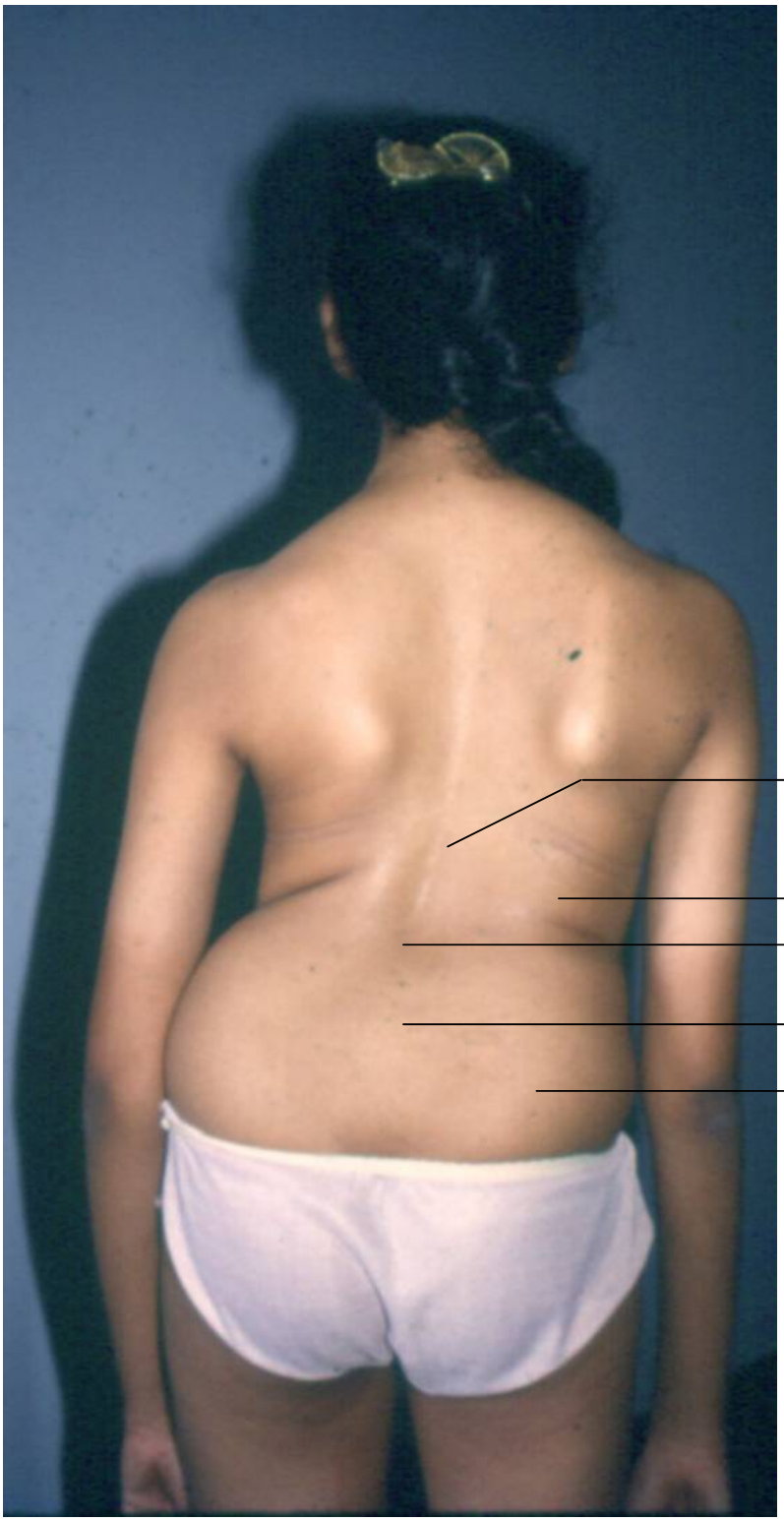
## Case 3 – Post op

**AP VIEW**



**LATERAL VIEW**

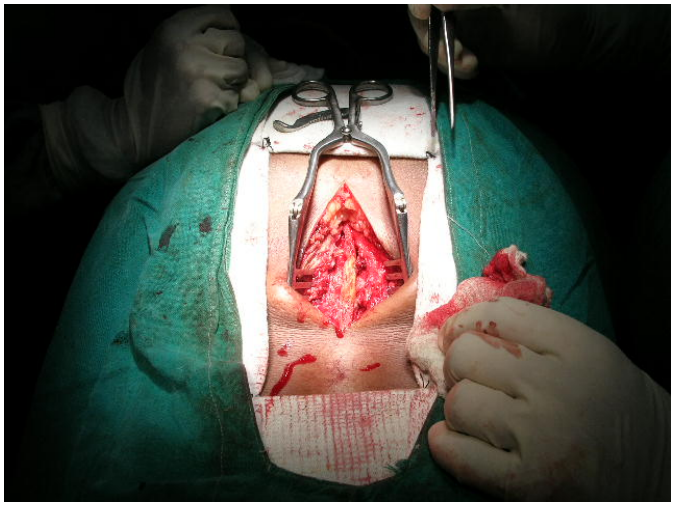
# SPONDYLOLISTHESIS – HIGH GRADE

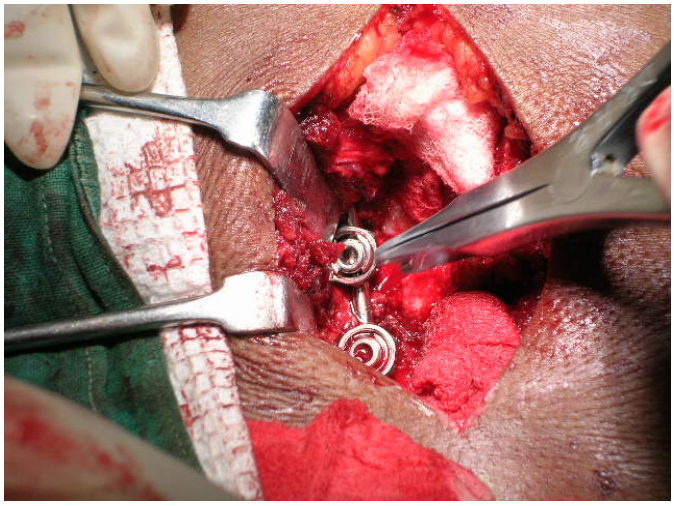


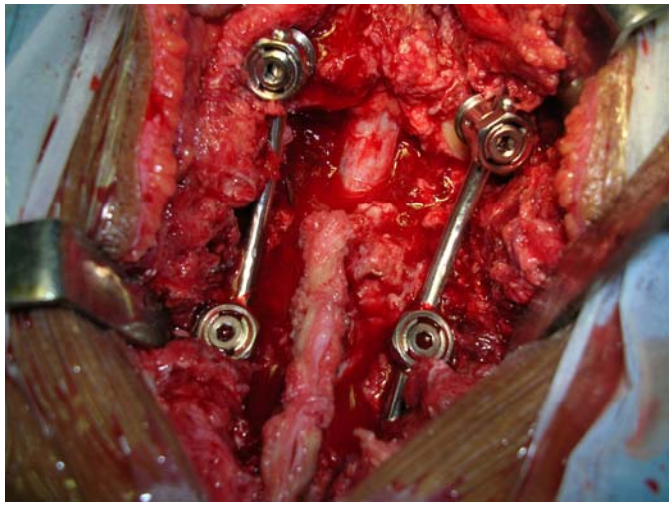
**“SCOTTY DOG” PROFILE VIEW**

**Decapitated Head of Scotty Dog**

# SURGICAL STEPS







# PROFORMA

**NAME:** **D.O.A.**

**AGE / SEX:** **D.O.S.**

**ADDRESS:** **D.O.D.**

**INVESTIGATIONS:**

PLAIN RADIOLOGY FINDINGS

STANDARD AP AND LATERAL

SPECIAL VIEW

MRI

**DIAGNOSIS:**

**PRE OP PLANNING:**

PEDICLE SCREW LENGTH

DIAMETER

**INTRA OP ASSESSMENT:**

ANAESTHESIA

POSITION

IMPLANT

DECOMPRESSION

REDUCTION

FIXATION

**OPERATING TIME**

**BLOOD LOSS**

**FLUOROSCOPIC EXPOSURES**

**INTRA OP COMPLICATIONS OR DIFFICULTIES**

**POST OP PERIOD**

**FOLLOW UP**

| S.No | Name | Age | Sex | I.P.No | Classification | dynamic instability | % slip | Correction Achieved | Operating time (hrs) | Blood loss (ml) | Fluoroscopic exposure (sec) | Time for Fusion (months) | Functional Outcome |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Neela | 35 | F | 429170 | III | + | 55° | complete | 3.55 | 240 | 62 | 11 | excellent |
| 2 | Nilofar | 38 | F | 429381 | III | + | 55° | complete | 3.3 | 220 | 38 | 9 | excellent |
| 3 | Saravana Kumar | 49 | M | 427523 | III | + | 63° | complete | 3.3 | 210 | 43 | 8 | excellent |
| 4 | Balamani | 44 | F | 424157 | IV | + | 77° | 30° | 4 | 310 | 54 | - | good |
| 5 | Pandeeswari | 52 | F | 423189 | III | + | 60° | complete | 3.25 | 260 | 44 | 10 | good |
| 6 | Saheela Banu | 44 | F | 431068 | IV | + | 70° | complete | 3.1 | 250 | 47 | 9 | good |
| 7 | Manoharan | 48 | M | 421721 | III | + | 57° | complete | 3.3 | 250 | 44 | 12 | excellent |
| 8 | Panju | 45 | F | 426129 | III | + | 58° | complete | 3.05 | 250 | 40 | - | good |
| 9 | Thothan | 48 | M | 431252 | III | + | 80° | 42° | 4.25 | 260 | 42 | 10 | good |
| 10 | Murugeswari | 43 | F | 425125 | III | + | 60° | complete | 2.55 | 190 | 38 | 11 | good |
| 11 | Pandiselvi | 50 | F | 425763 | III | + | 58° | complete | 3.55 | 200 | 36 | 9 | excellent |
| 12 | Petchiammal | 44 | F | 431279 | III | + | 70° | complete | 3.2 | 200 | 42 | 10 | good |
| 13 | Muthulakshmi | 42 | F | 421652 | IV | + | 77° | 35° | 4 | 240 | 42 | - | good |
| 14 | Meena | 40 | F | 425726 | III | + | 72° | complete | 3.2 | 220 | 40 | 8 | excellent |
| 15 | Thanalakshmi | 42 | F | 431709 | III | + | 67° | complete | 3 | 150 | 38 | 9 | excellent |